Forecasting and Monitoring Intense Thunderstorms in the Hindu-Kush Himalayan Region

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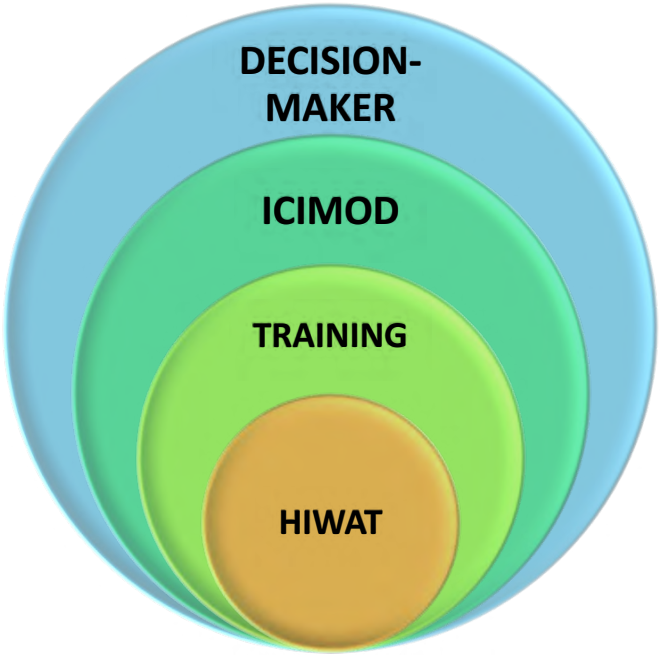
Project Overview

Goal: Use NASA Earth Observing System (EOS) assets to build early warning capabilities and facilitate timely disaster response for high impact weather events in the Hindu-Kush-Himalaya (HKH) region

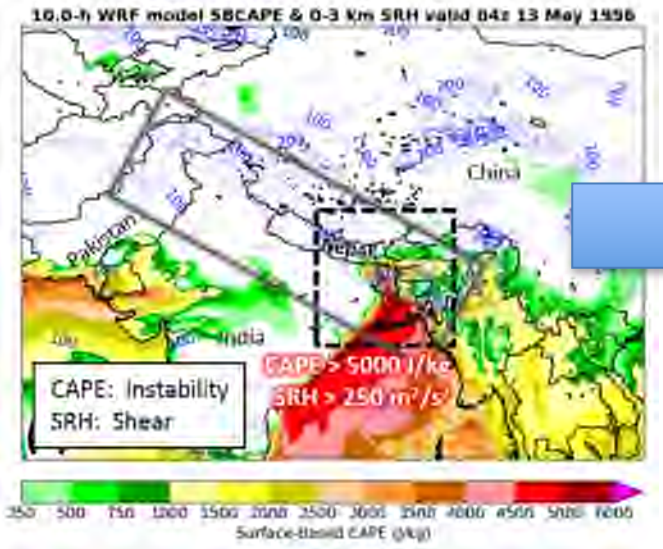
Objectives:

1. High-Impact Weather Assessment Toolkit (HIWAT) for the HKH region
2. Jointly develop HIWAT capabilities / training with ICIMOD
3. Demonstrate capability in end-user environment
4. Transition HIWAT to ICIMOD



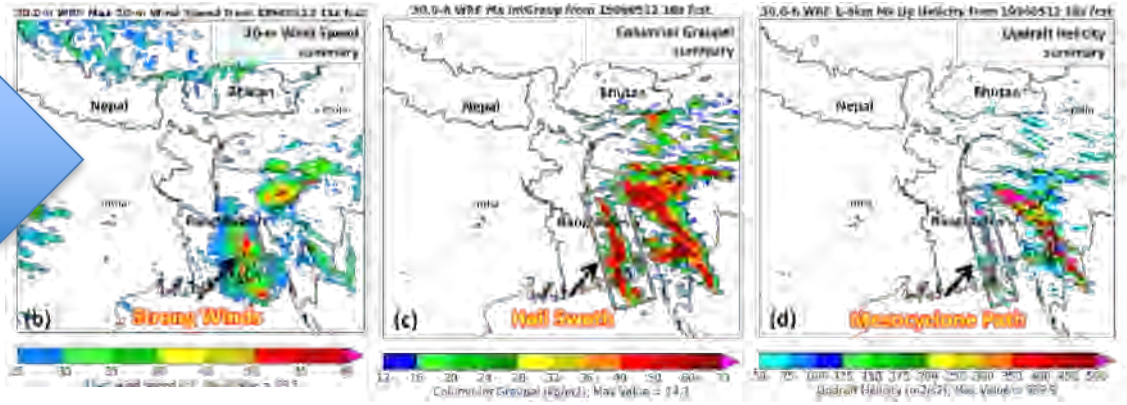
What is HIWAT?

REGIONAL NWP MODEL



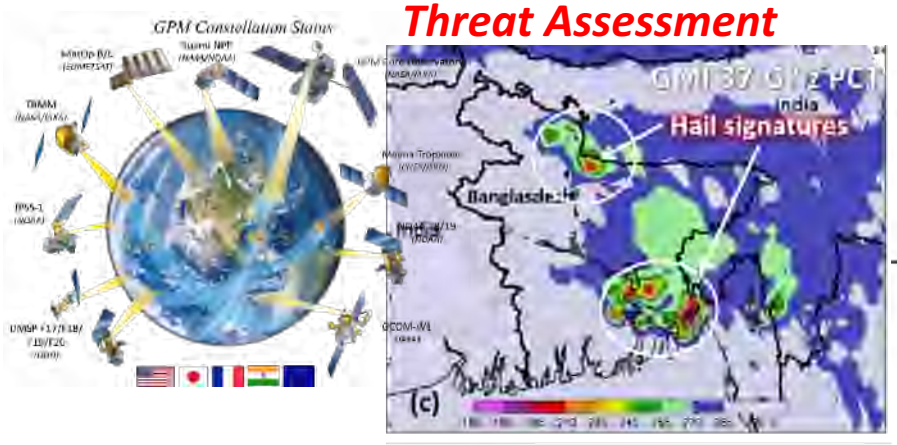
HIGH-IMPACT WEATHER ENSEMBLE PROGNOSTICS

Short-term forecasting



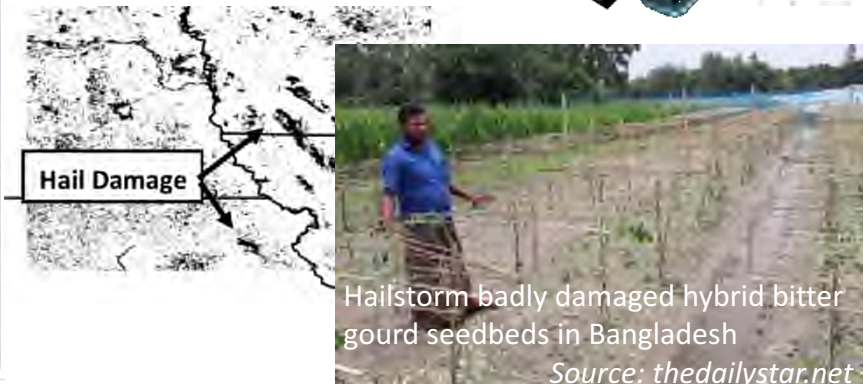
GPM OBSERVATIONS

Threat Assessment



LAND IMAGERY

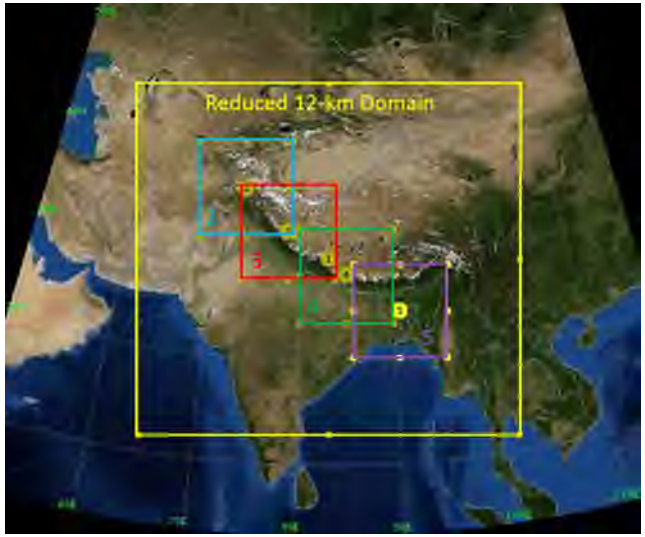
Impact Assessment



Thunderstorm Hazard Forecasting

Operations concept for focus regions:

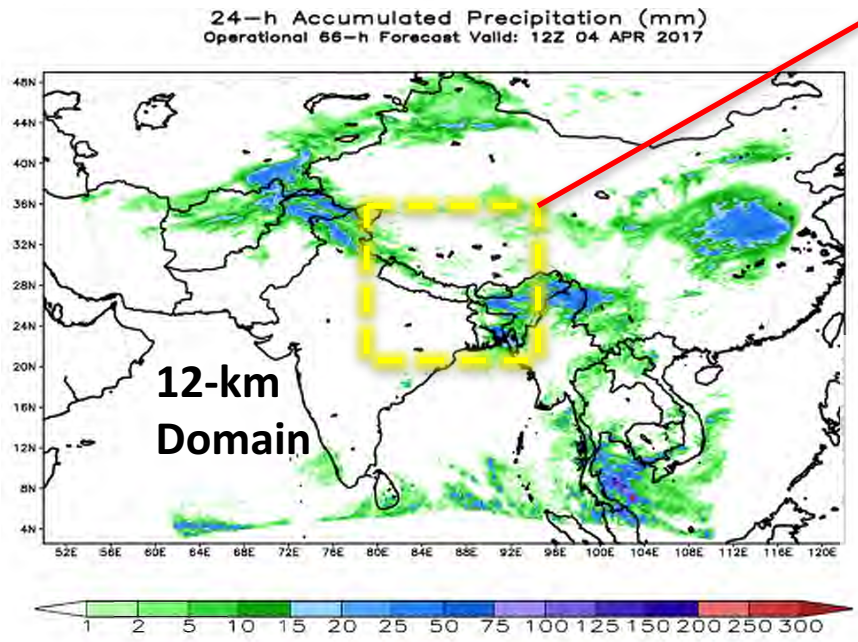
- Daily 12-km/4-km deterministic run
  - Three-day simulation of Weather Research and Forecasting (WRF) model
  - Model output of environmental parameters favoring severe thunderstorms & flooding threats
    - Severe thunderstorms: SCP/STP/DCP/SHIP
    - Flooding: Precipitable water/QPF/moisture convergence
    - Pre-configured nested domains for running convection-allowing model (CAM) ensemble (bottom)

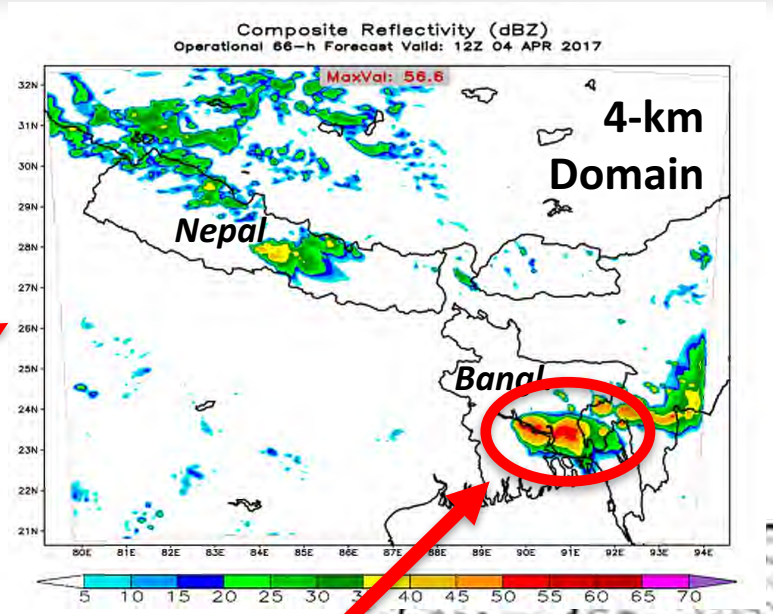


- ***On-demand*** CAM mini-ensemble
  - 12 members with different ICs & model physics
  - Paintball & probability maps of various hazards
  - Triggered based on nest with greatest hazard coverage of severe parameters
  - Potential application of cloud computing

Stepping Through Event: 4 Apr 2017

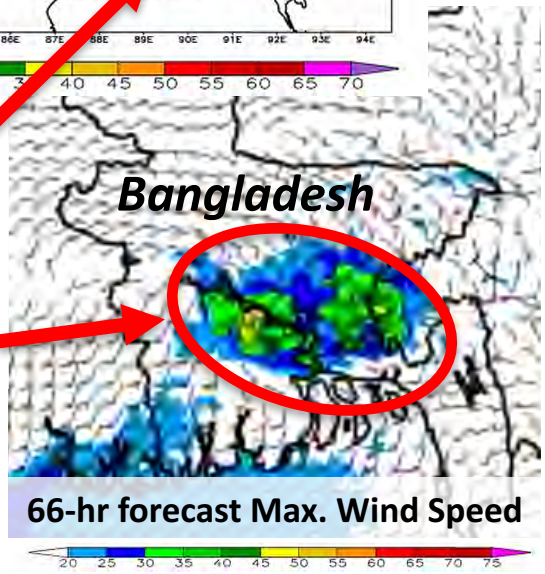
Example of WRF forecast 2-days prior to a high-impact weather event across central / southern Bangladesh on 4 April 2017





Intense Thunderstorms

Damaging Winds



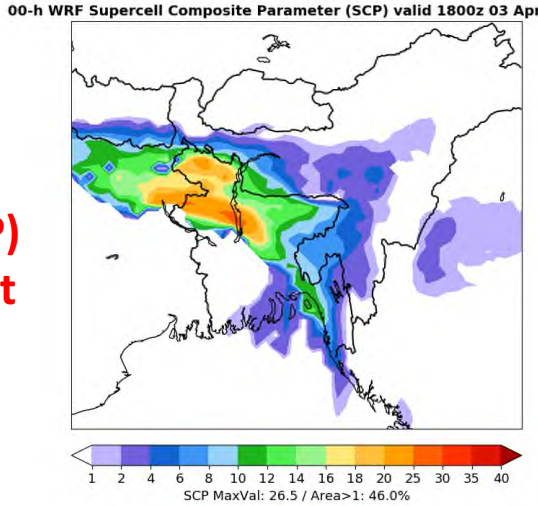
Take-away: ***Model doing a good job capturing intense thunderstorm events***

42nd National Weather Association annual meeting; Garden Grove, CA; 16-21 Sep 2017; Session G: Remote Sensing

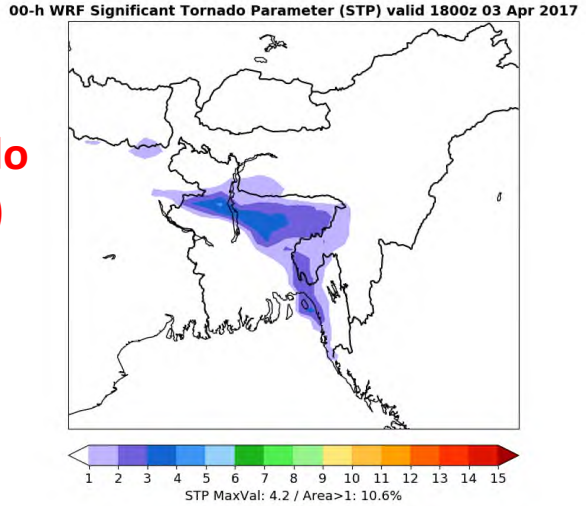
Stepping Through Event: 4 Apr 2017

Deterministic 12-km WRF model output of severe thunderstorm indices

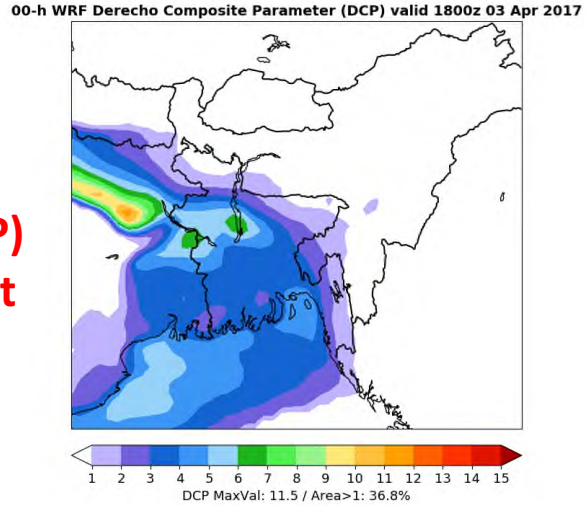
Supercell Composite Parameter (SCP) 3-hourly output



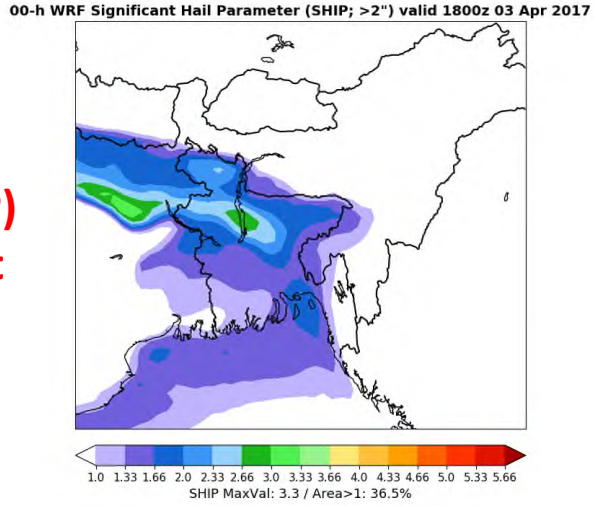
Significant Tornado Parameter (STP) 3-hourly output



Derecho Composite Parameter (DCP) 3-hourly output



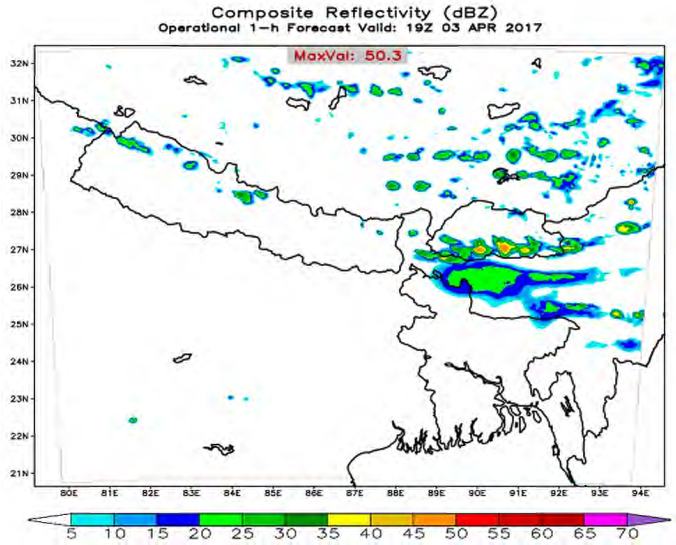
Significant Hail Parameter (SHIP) 3-hourly output



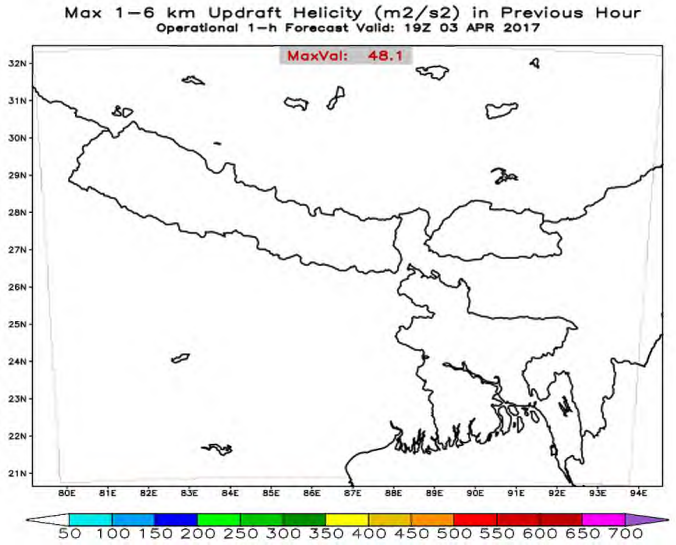
Stepping Through Event: 4 Apr 2017

Deterministic 4-km WRF output of specific severe thunderstorm hazards

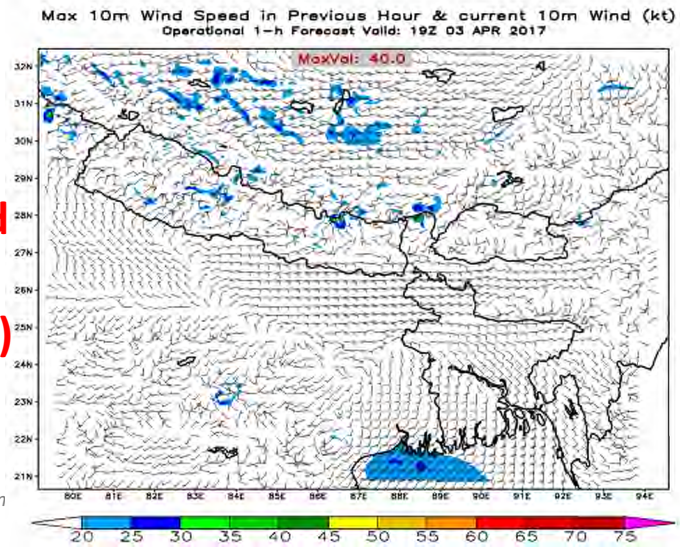
Simulated Reflectivity



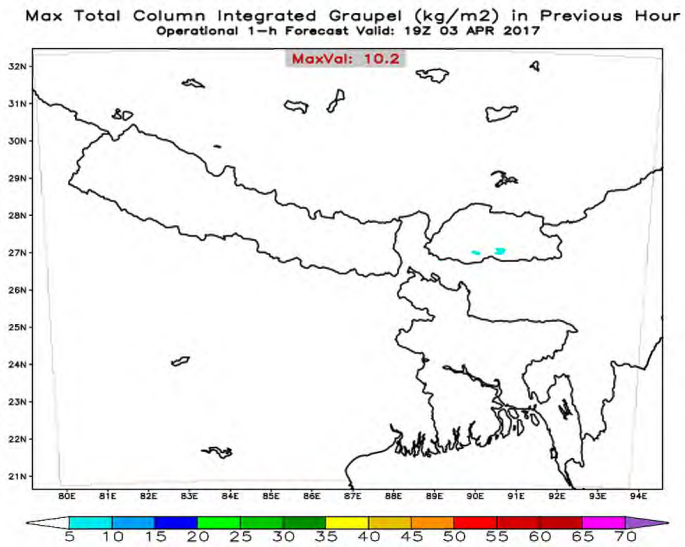
Updraft Helicity (mesocyclone proxy)



Max 10-m Wind Speed (damaging wind threat)



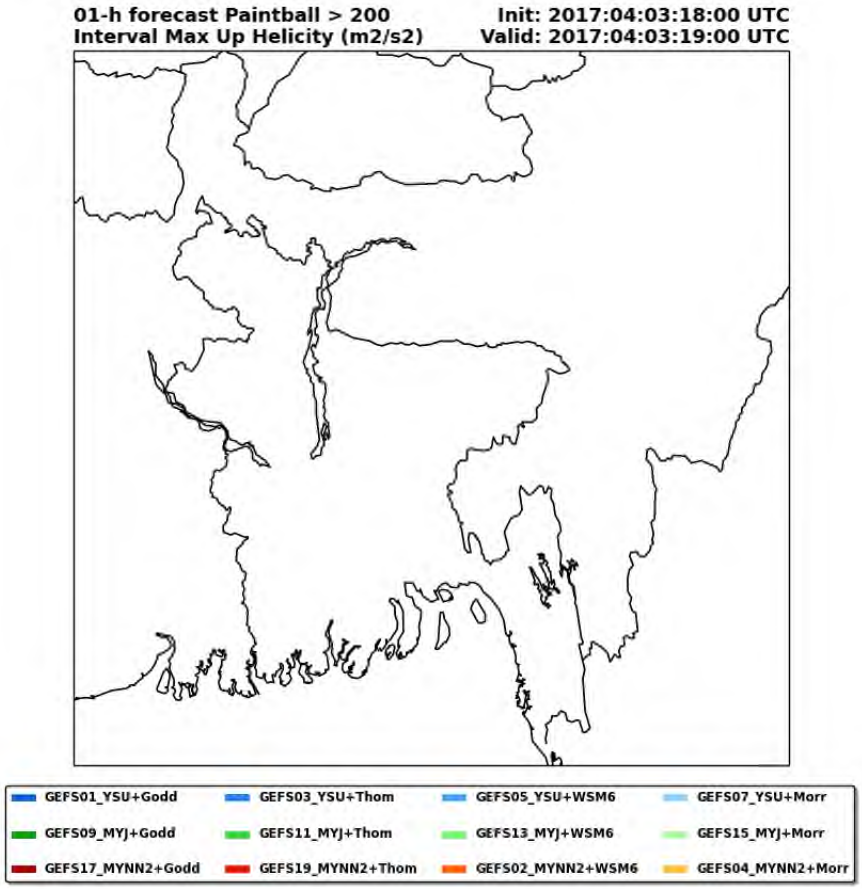
Max Total Column Graupel (hail proxy)



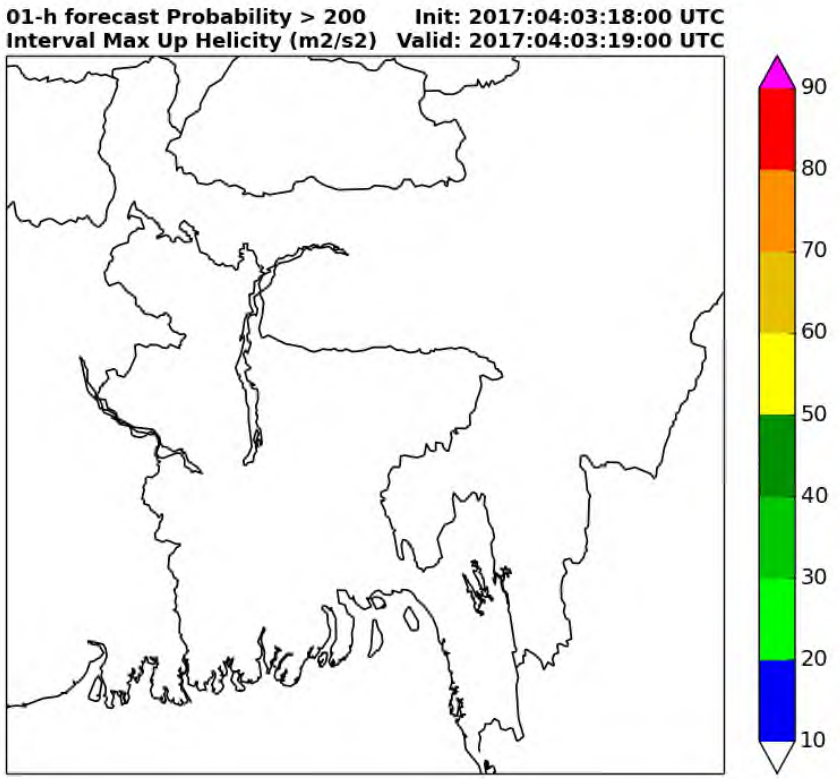
Stepping Through Event: 4 Apr 2017

Select 4-km ensemble fields: Updraft Helicity (meso/tornado threat)

Updraft Helicity
"Paintball" > 200 $m^2 s^{-2}$ animation



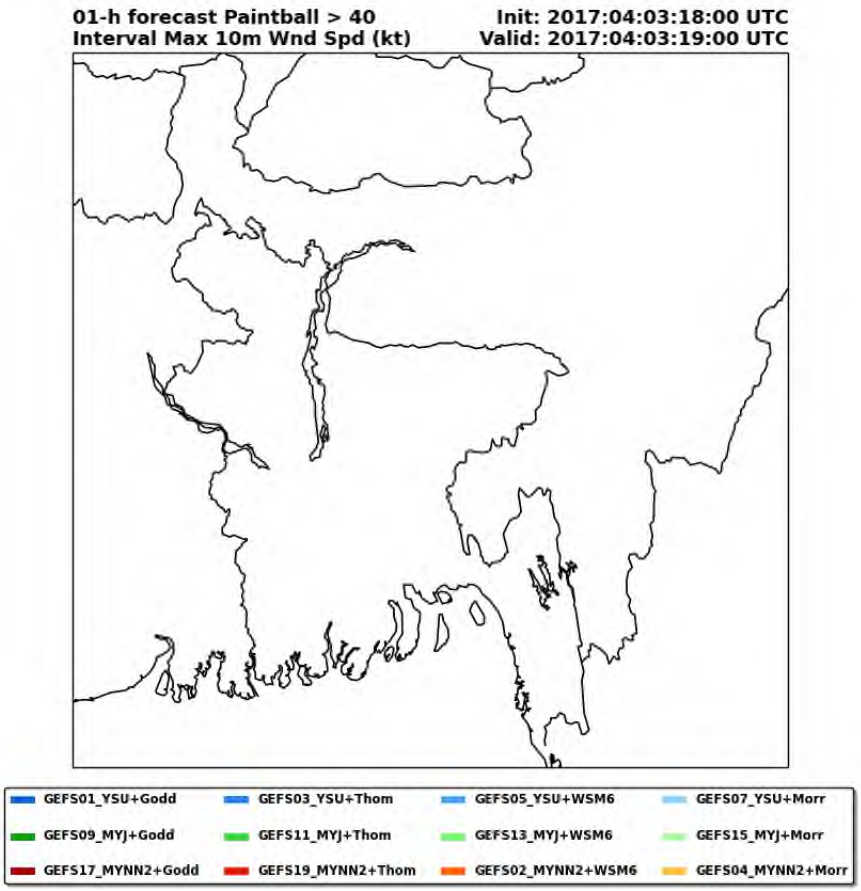
Updraft Helicity
Probability > 200 $m^2 s^{-2}$ animation



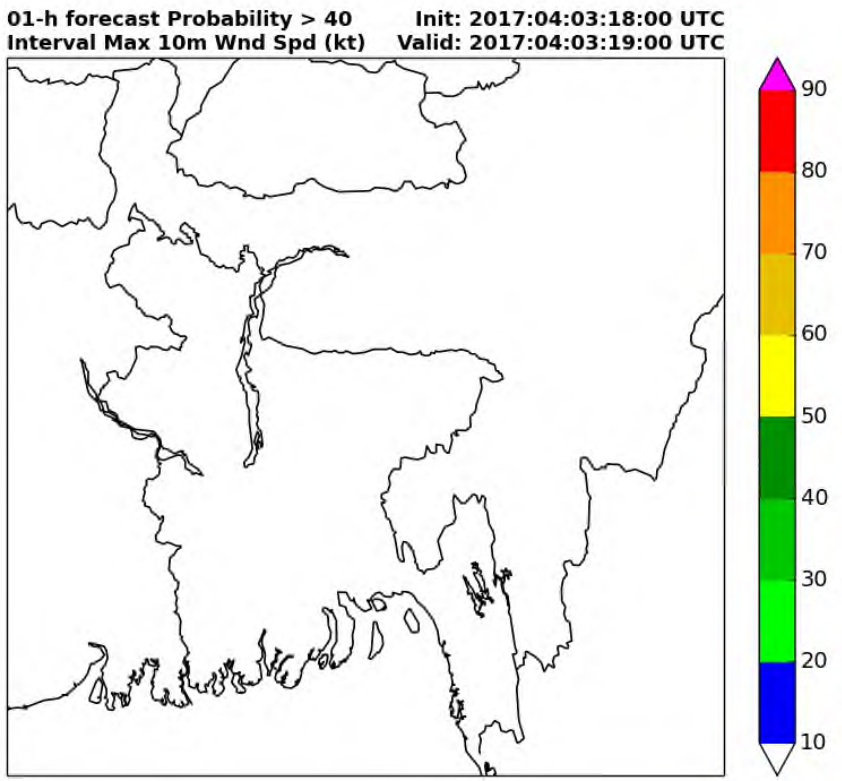
Stepping Through Event: 4 Apr 2017

Select 4-km ensemble fields: Max 10-m Wind (damaging straight-line wind)

Max 10-m Wind Speed
"Paintball" > 40 kt animation

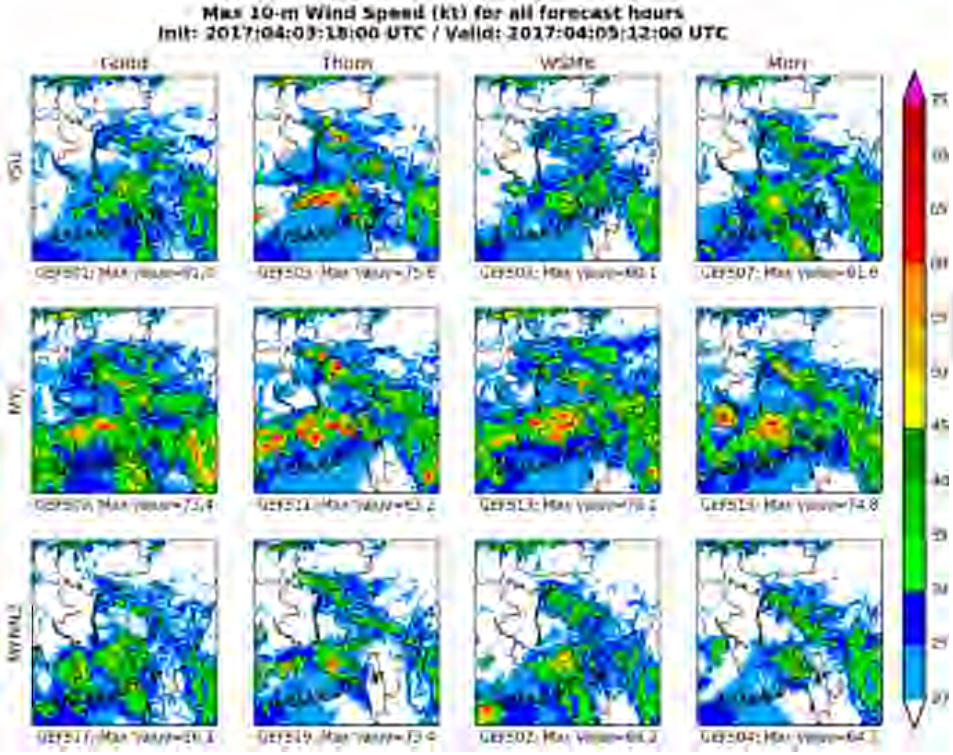


Max 10-m Wind Speed
Probability > 40 kt animation

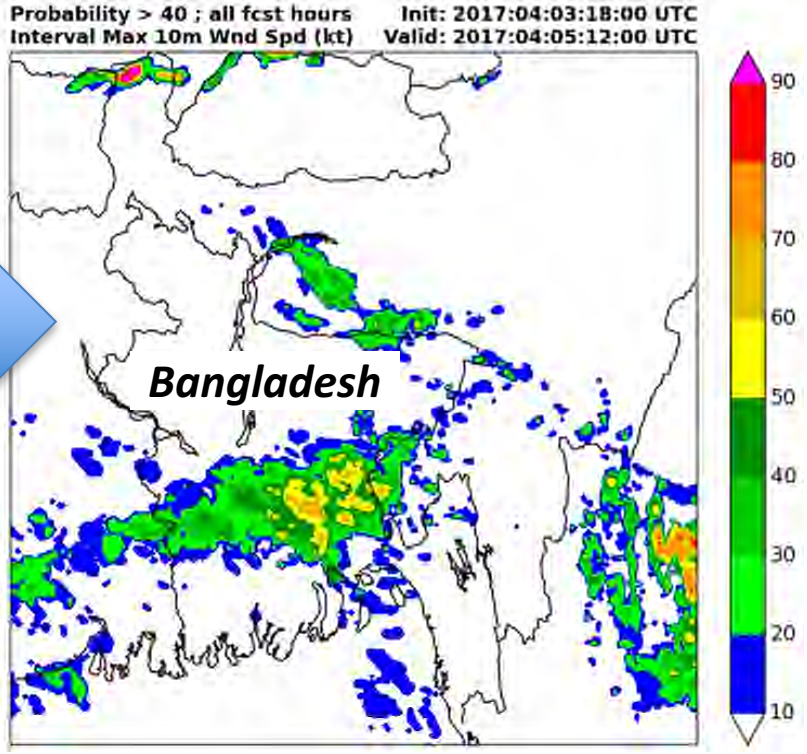


42-hour Ensemble Summary Fields

Thumbnail view: Max 10-m wind at any fcst hour



Probability of damaging wind > 40 kt

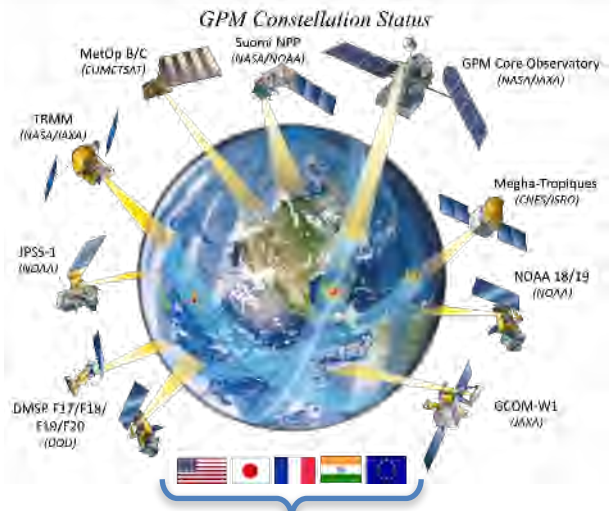


- Ensemble capabilities readily provide *probabilistic-based* information for decision-makers (i.e., value-added information)
- Computational requirements benchmarked for deterministic and ensemble runs

Damage and Injuries from 4 April

Damage in central Bangladesh from nor'wester/tornado event that damaged ~400 houses and injured 150 on 4 April 2017.

Satellite-based Assessment Tools to Supplement Model Forecasts



GPM-based storm intensity:

- **Sub-setting GPM constellation over HKH**
- **Hail probability algorithm**

PPS

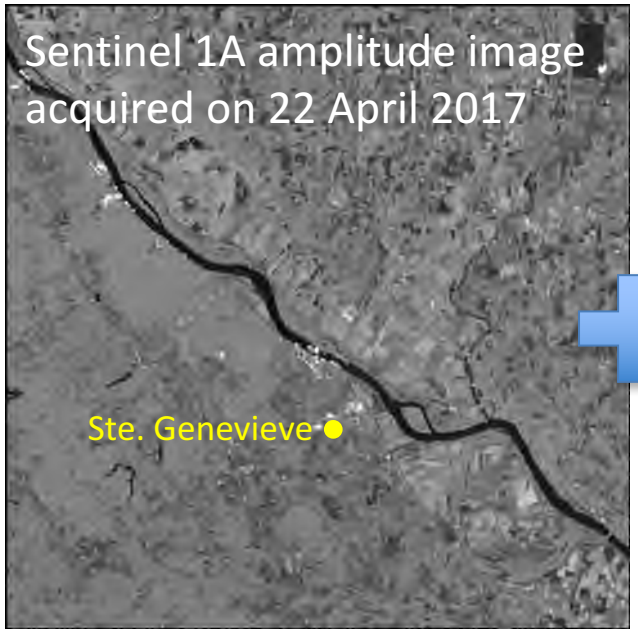
SUBSETS DATA

HAIL PROB. ALGORITHM

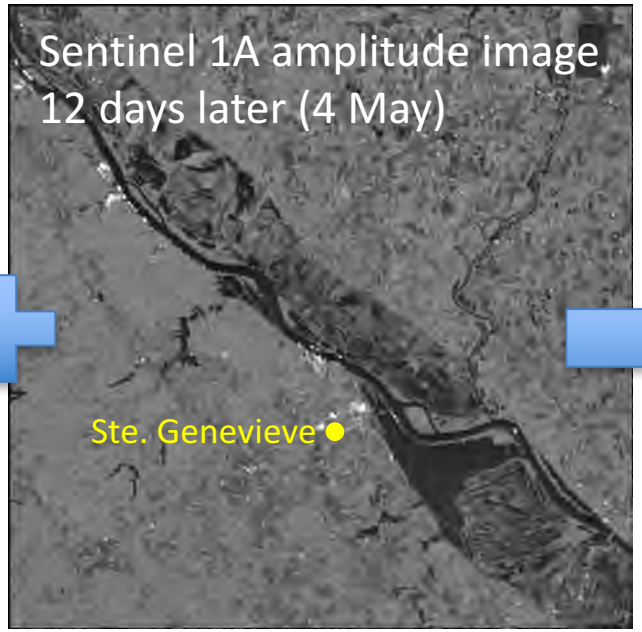
SAR-based damage assessment
(Bell et al.; Thursday Poster Session 3)

Damage and inundation mapping for model validation/disaster response:

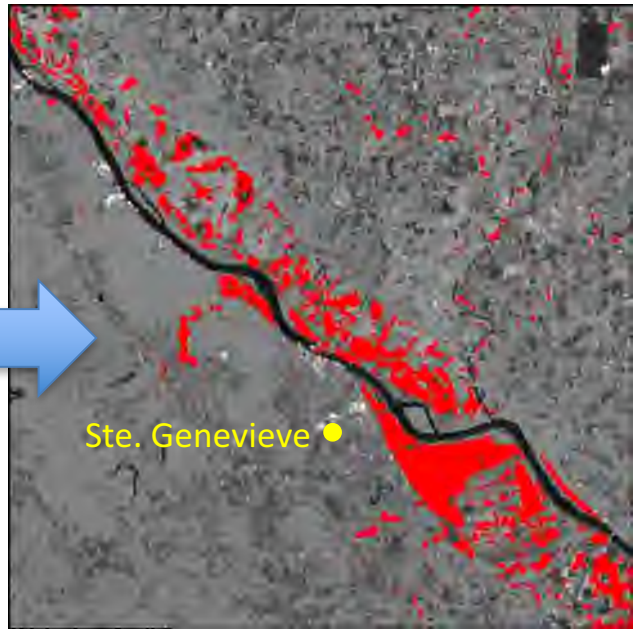
- Seeking to apply value-added Synthetic Aperture Radar (SAR)-based products
  - SAR facilitates product reliability (i.e., *regardless of sky conditions* or *time of day)*
- Collaborating with the Alaska Satellite Facility (ASF) to create SAR product workflows
  - ASF is a NASA data center for Sentinel → reduces burden to download large datasets



SAR image prior to April 2017 Missouri flooding event along Mississippi River



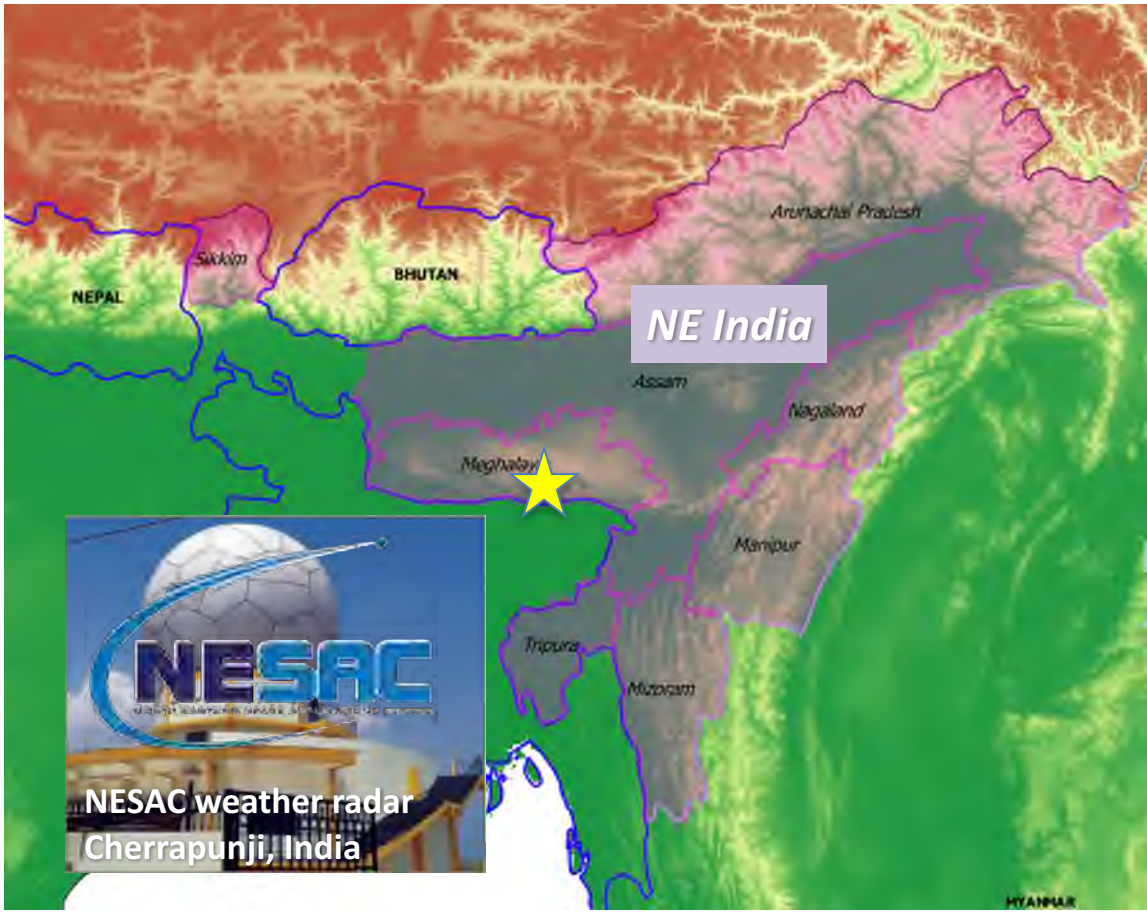
Ongoing flooding, denoted by darker areas in proximity to the river.



Change detection product determines areas (red) that meet prescribed threshold to denote inundation.

Next Steps

- Real-time CAM ensemble-based thunderstorm hazards prediction
- Hail probability maps from satellite-based microwave (GPM) measurements over HKH
- Satellite-based damage assessment maps using SAR data across HKH
- Collaboration with Northeastern Space Applications Centre:
  - Thunderstorm modeling
  - Model validation with S-band dual-pol Doppler radar in Cherrapunji, India (right)



Thank you!!

Question and Comments Welcome!

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